Strategic Bidding in Multi-unit Auctions with Capacity Constrained Bidders: The New York Capacity Market

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Motivation

- Offer empirical support for a simple model of bidding behavior in multi-unit uniform price auctions (capacity markets).
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- Show that in the NY capacity market, observed bid patterns from 2003 to 2008 result from strategic firm behavior.
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• The product is the availability of power plants, which commit to offer electricity for a specified time-horizon.

• The regulator/ISO finances these auctions by passing the procurement costs on to end-users.
NYISO Energy Markets

- Energy market with LBMP

- Three NYISO administered capacity markets, including forward markets for ICAP (this paper looks at the NYC ICAP market)
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Figure 1: ICAP Demand Curve winter 2010, taken from NYISO.com.
The NYISO Energy Market: Forward & Spot ICAP Markets

- Market participants can engage in bilateral or institutional forward markets for ICAP, must notify their position to the NYISO, who procures the missing ICAP in its monthly ICAP spot auction.
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Figure 2: Forward and spot sales example, taken from NYISO.com.
Data

The data stems from the New York City capacity market:

- 55 monthly multi-unit uniform price procurement auctions
- June 2003 until March 2008
- 1093 bids
- Bidder ID, functional form of demand, bid caps

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<td>offer share three largest firms</td>
<td>89.0%</td>
<td>65.0%</td>
<td>100%</td>
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Table 1: Auction statistics.
Example: Auction Outcome

Figure 3: Auction August 2006.
Green and Newbery (1992), Hortacsu and Puller (2008) show how firms compete in SFE.
Modelling

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• Fabra et al. (2006) show how firms with discrete supply offers compete (low/high bidders)

• Model relies on Fabra et al. (2006), perfect information with marginal costs being normalized to zero
The Model

...calculates bounds for infra-marginal bids.

Figure 4: Auction August 2006, with bounds for low bids.
The Model

...calculates bounds for infra-marginal bids.
...and derives an asymmetry condition for the largest firm to be pivotal.

Figure 4: Auction August 2006, with bounds for low bids.
Results: The Pivotal Bidder

- The pivotal bid equals the bid cap in all auctions.

- In all auctions, the largest bidder is the pivotal bidder.

- In all auctions, the condition for sufficiently asymmetric firm sizes holds.
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Results: The Infra-marginal Bidders

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• Roughly 95% of all low bids are explained by the model.

• Much violations happened in the first five auctions: learning?
Results: The Infra-marginal Bidders

- Low bids were mainly submitted either at zero or just below the bound.

Figure 5: Histogram bid-bound ratio.
Results: The Infra-marginal Bidders

OLS regressions for best response functions of low bids:

- The pivotal bidder earns $\pi_p$.
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OLS regressions for best response functions of low bids:

- The pivotal bidder earns $\pi_p$.
- When undercutting, this bidder sells either all capacity, $k_p$, or serves residual demand at a lower price, $D(b_j) - K_j - 1$. 

Coming from the model, estimate:

$$\ln(b_j) = \beta_0 + \beta_1 \ln(\pi_p) + \beta_2 \ln(D(b_j) - K_j - 1) + \ldots$$
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Results: The Infra-marginal Bidders

- Low bids react to the pivotal bidder’s capacity.

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\(t\) statistics in parentheses

* \(p < 0.05\), ** \(p < 0.01\), *** \(p < 0.001\)
Conclusion

- When firms are capacity constrained, simple models are sufficient to predict bidding behavior in multi-unit auctions.

- Capacity markets, when organized in this form, are a costly tool to enhance security of supply.

- In the market studied, without strategic bidding, the auctioneer could have saved around 40% procurement costs.
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THANK YOU!
Appendix: The Model

The pivotal bidder finds

$$b_p^* = \min\{\arg\max_b b (D(b) - K_{p-1}), b^{cap}\},$$

while the low bidders have to bid lower than

$$\bar{b}_j := \begin{cases} 
  b_j (D(b_j) - K_{j-1}) = \pi_p & \text{if } \bar{k}_p > D(b_j) - K_{j-1} \\
  b_j \bar{k}_p = \pi_p & \text{if } D(b_j) - K_{j-1} > \bar{k}_p.
\end{cases}$$

to not be underbid by the pivotal bidder.
Appendix: Low Bid Profit Equivalence

- There is no significant relation between amount of capacity bid and distance to its bound.

Figure 6: Bid-bound ratio over submitted capacity.
Appendix: Results Pivotal Bids

- The bid cap is binding in nearly all auctions.

Figure 7: Unconstrained optimal and observed high bids.
Appendix: Counterfactuals

- With truth-telling (or no withholding), the auctioneer could have saved around 40% of procurement costs while at the same time procuring more capacity.

- With properly adjusted bid floors, the observed equilibria can be destroyed and auction prices lowered.
Appendix: Bid Floors

- As capacity constrains are relaxed, bid floors become more effective.

Figure 8: Auction prices with bid floors.